AIT-WATCHMAN

Applied Antineutrino Physics 2018

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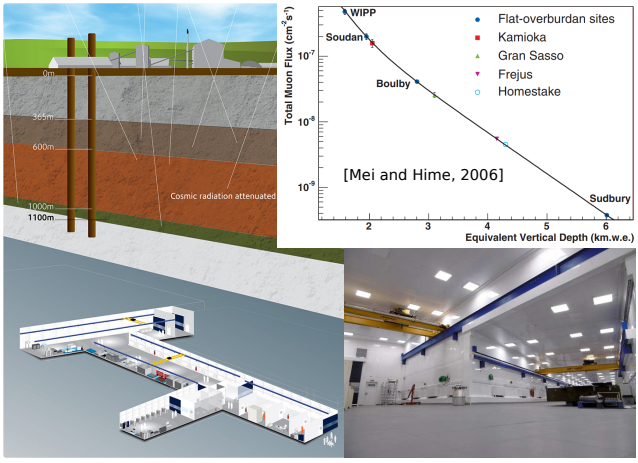
Water **Ch**erenkov **M**onitor for **An**tineutrinos (**WATCHMAN**)

Objective: Demonstrate nuclear reactor monitoring for non-proliferation purposes through antineutrino detection using a large, scalable, technology (Gd doped water).

Detector to be located at Boulby Mine

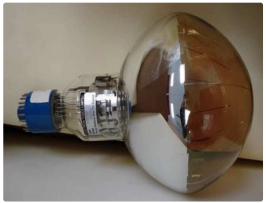
- 25 km from Hartlepool (2x 1500 MWt reactors)
- Deep underground (2805 m.w.e.)
- Well established scientific program (ZEPLIN, NAIAD, DRIFT, BUGS)

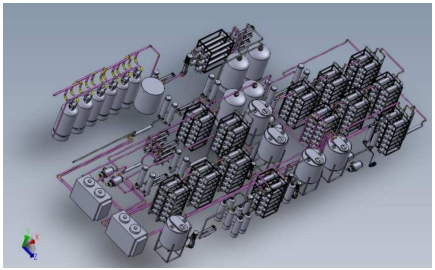


Conceptual detector design

~4000 HQE low background PMTs (U/Th content reduced by a factor of 10).

100 delivered and being characterized.



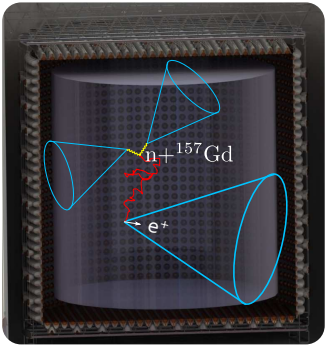


Custom water filtration system designed by South Coast Water based on the EGADS design.

~2.6 kB Detection Capability.

1 kton Gd+H2O fiducial volume

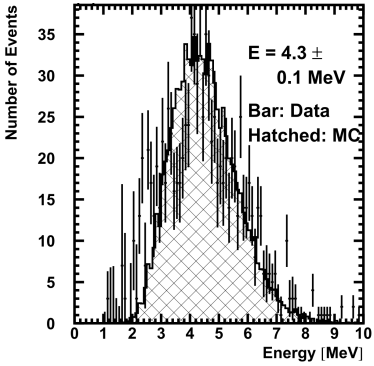
$$\bar{\nu}_e + p \rightarrow e^+ + n$$



Gadolinium Development

Technology is well understood.

1. Neutron capture measured at LLNL in water[1].
2. Daya Bay / Double Chooz / RENO used Gd to detector $\bar{\nu}_e$ in liquid scintillator.
3. EGADS demonstrated good optical properties and long term stability of Gd in water.
4. WATCHMAN and Super-Kamiokande will use Gd doped water.

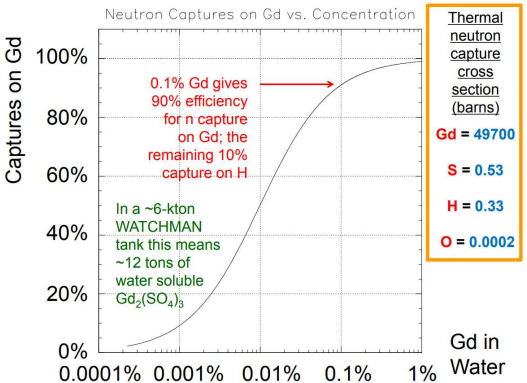


Measurement of reconstructed (n,Gd) in Super-Kamiokande. [Watanabe et al., 2009]

[1] [Dazeley et al., 2009]

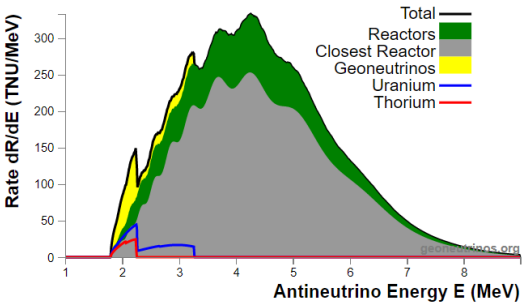
Gadolinium Loading

- Goal is to load 0.1% Gd into the water.
- This technology was developed for Super-Kamiokande and thoroughly tested in EGADS.
- The water retains its optical properties while becoming an efficient neutron detector.
- Target loading will provide 90% capture on Gd.



Prominent background components

Antineutrino Backgrounds



Produced at `https://geoneutrinos.org/` with one reactor core turned off [Barna and Dye, 2015].

High-rate Single Events (Random Coincidence)

- Bi^{214} + Tl^{208} from detector components (Water, PMTs, Steel structure, ...)
- Radon contamination

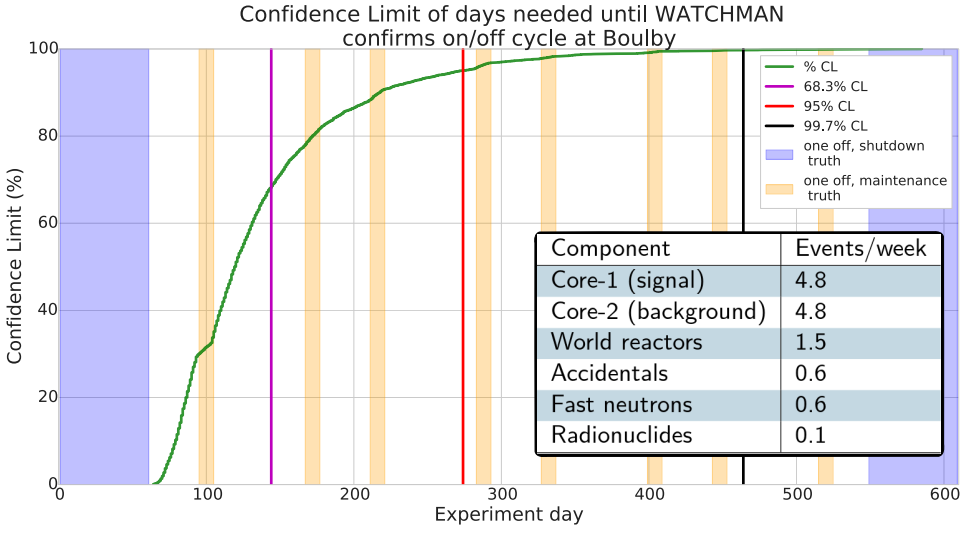
Irreducible / Coincidence

- Reactor $\bar{\nu}_e$ from other reactor.
- Terrestrial $\bar{\nu}_e$
- Cosmogenic radionuclides
- Cosmogenic neutrons

WATCHMAN analysis goals

1. Perform the experiment with full knowledge of both reactors' ON/OFF status (unblinded).
2. Perform the experiment with knowledge of a single reactor as a background, with a remaining unknown reactor.
3. Perform the experiment with no knowledge of either reactor (fully blinded).

Dwell time



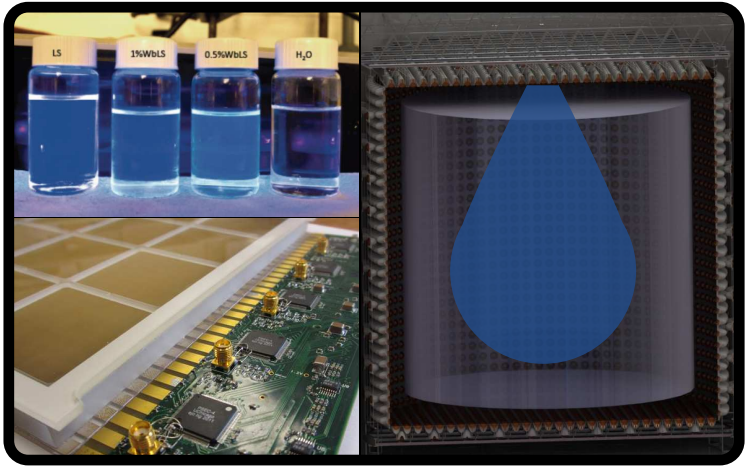
Component	Events/week
Core-1 (signal)	4.8
Core-2 (background)	4.8
World reactors	1.5
Accidentals	0.6
Fast neutrons	0.6
Radionuclides	0.1

Advanced **I**nstrumentation **T**estbed

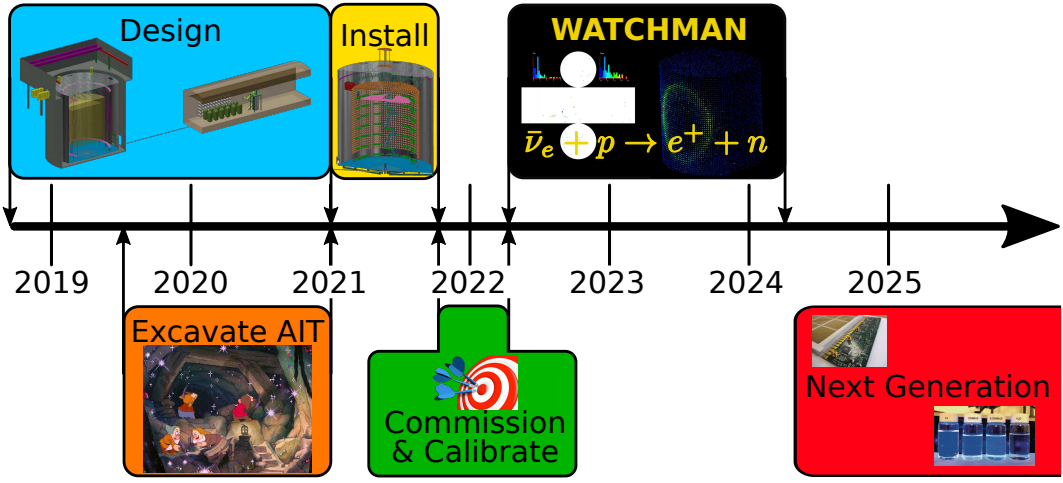
AIT—Encompassing WATCHMAN and future upgrades

Detector designed to operate beyond WATCHMAN with potential future upgrades.

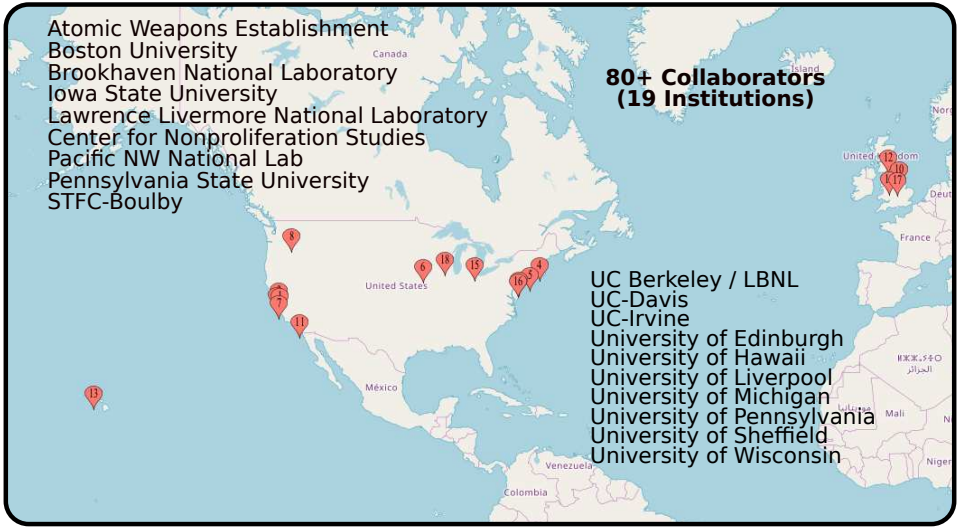
1. Water-based liquid scintillator.
2. Fast photo-sensors
3. Internal deployment



Project Timeline



The AIT-WATCHMAN collaboration



Conclusions

1. The WATCHMAN design is being finalized with construction to commence shortly thereafter.
2. First large scale antineutrino detector designed to monitor nuclear reactors for non-proliferation purposes.
3. AIT will extend the use of the WATCHMAN detector beyond reactor monitoring.
4. Collaboration is rapidly growing.

Questions?

References

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